Space Weather Technical Forecast

Issued on Monday, 23 January 2023 at 12:39 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Reducing risk of R1/R2 Radio Blackouts and G1/Minor Geomagnetic Storms after midweek (UTC).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate during the past 24 hours, with two M-class flares observed at GOES16. The largest of these events was an M2.7 observed at 22/1701UTC from AR3194 in the southwest quadrant, preceded by a longer period M1.1 at 22/1227UTC from AR3190.

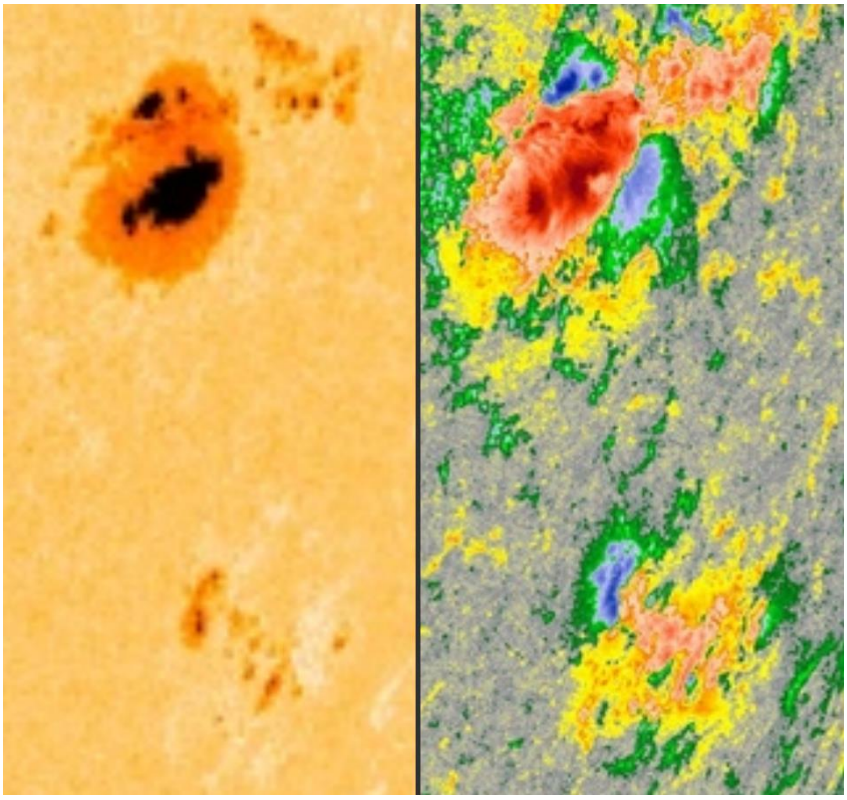

Figure 0: HMIIF and HMIBC imagery as at 23/1100UTC showing the two most active sunspot regions of the past 24 hours: AR3190 (top) and AR3194 (bottom). Note the presence of a Mt Wilson delta spot as part of the largest penumbral grouping in AR3190.

There are currently nine sunspot regions on the visible disc, possibly now joined by a new unnumbered region on the northeastern limb. The northern solar hemisphere is currently the preserve of numerous diffuse bipolar regions that straddle 20 North, with those in the east generally non-productive in terms of flares in the past 24 hours, however those in the west did display some UTC evening flare activity.

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The southern solar hemisphere has its efforts concentrated in the southwest by contrast, with the two most-changed groups occupying this sector. These include the large AR3190, which currently exceeds 1000mhs in area thanks to a large central spot, with this appearing to contain a Mount Wilson Delta in its northern portion. This group saw the fading of numerous small trailing spots in the period, eventually replaced by a similar distribution of leading spots. Also of note was AR3194, which saw its central spots changing over short timescales, perhaps helping to produce the peak flare of the period.

There are currently numerous filaments on the solar disc, with most of these concentrated near the western solar limb in both hemispheres, which is of note as they could be triggered by the more active sunspots here should they flare appropriately. Coronagraph imagery in the period showed numerous small CMEs emerging from the west and southwest - at the time of writing none of these have been assessed as having an Earth-directed component. After 23/0500UTC, a southeast-directed CME appeared with a possible halo shock, which is currently thought to be far-sided and off the Sun-Earth line but will be assessed in due course. No new Earth-directed CMEs were therefore in evidence at the time of writing.

Solar Wind / Geomagnetic Activity: Solar winds speeds, as measured at L1 by ACE and DSCOVR showed a relatively noisy trace within Slightly Elevated to Elevated levels, rising from the mid-400s of km/s to the low 500s by the period's end. These were suggestive of an initial waning fast wind, probably that from CH68/+, which then saw a small discontinuity at 23/0300UTC at L1 which may suggest influence of one of the expected CMEs, perhaps most likely that from 19 January.

The solar wind density rose from single figures ppcc to low double figures over the same period. The IMF showed the most noteworthy behaviour in the 24 hours, with the 0300UTC discontinuity most marked here, rising from near 6nT to 11nT, while the north-south component varied between -8 and +11nT. The Bz component was mainly co-aligned with the Earth's field to limit geomagnetic impacts (thus far), while the phi angle changed from mainly positive (away from the Sun) to become more chaotic and then negative after 23/0300UTC.

The net effect of the above solar wind measures was Quiet to Unsettled, with a provisional peak Kp of '3o' in the 18-21UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at Background levels throughout.

High energy electron flux (greater than 2 MeV) has been at Normal Background to Moderate levels. The 24-hour integrated electron fluence stayed well below the Active threshold on a slowly increasing trend, with 7.7e6 integrated pfu observed at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Moderate, with the most potent regions in the southwest. These should rotate off the disc after midweek UTC to slightly reduce the daily chances of M-class activity.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is of lower than average confidence for the period: both due to marginal influence of a number of CMEs before midweek, and also a non-persistent coronal hole. Initial Likely Minor Storm G1 conditions should become less prevalent as the week progresses (barring significant developments), especially as the filaments and more-active southwest quadrant spots rotate away from the Sun-Earth line.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly Background levels, but with a Slight

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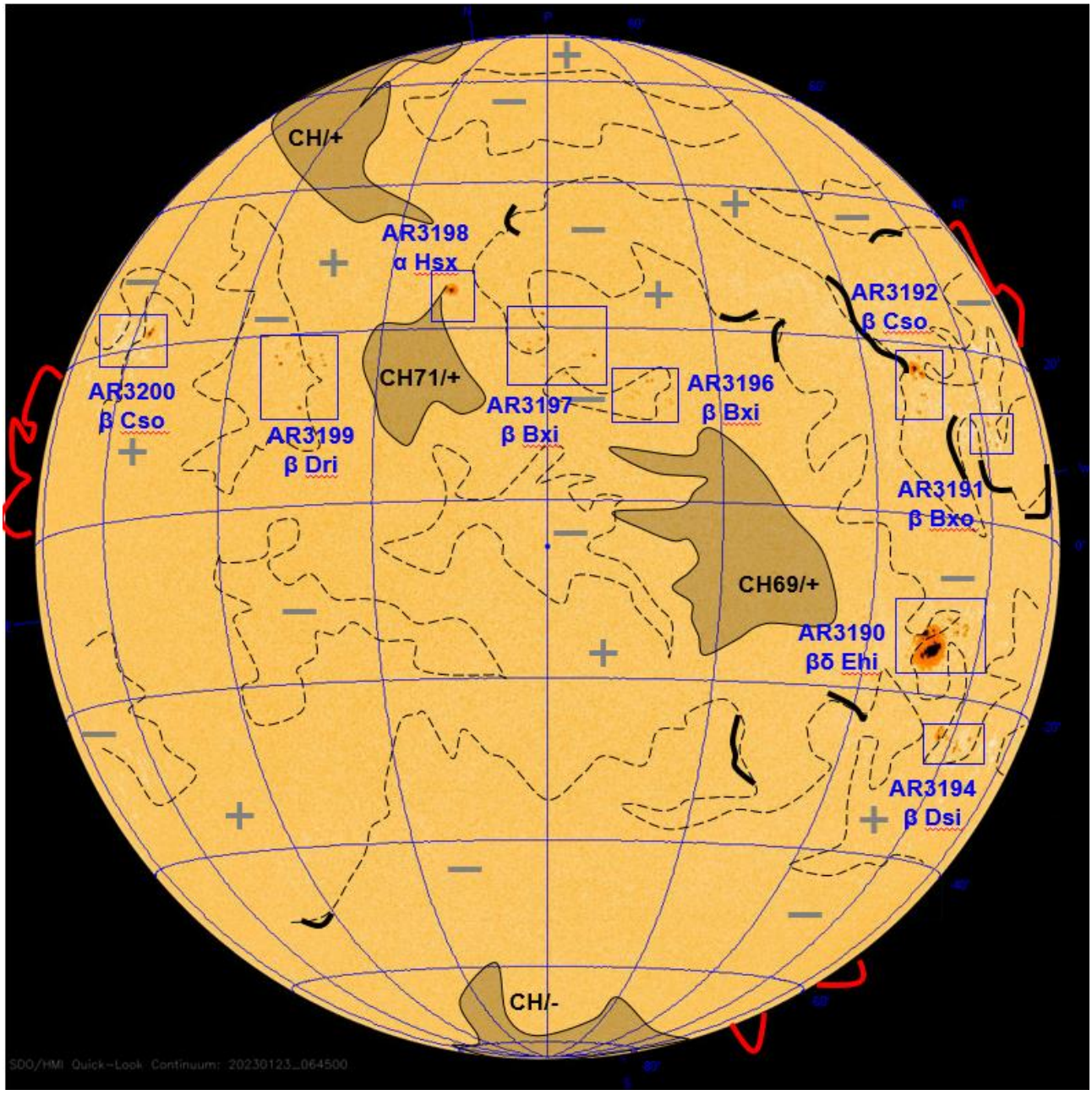
Chance of reaching S1 or greater through the period.

Electron flux should remain at Normal Background to Moderate levels, as at present, although this carries low confidence due to a number of CMEs and a non-persistent coronal hole fast wind due in the period. The greatest likelihood of surpassing Active fluence should arrive after midweek UTC and the expected fast wind, with the effect on electrons rated as an eventual Chance of Active fluence at peak.

Figure 1. Solar Analysis Valid 23/0645UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

The geomagnetic forecast is of low confidence for the period as a whole - a consequence of a number of CMEs with significant uncertainties attached early in the UTC week, and then a non-persistent coronal hole currently mooted for 24 January.

The roster of possible CMEs includes a faint emission from 19 January and up to two further events from 20 January, with these final two mainly directed below the ecliptic plane. Any or all of the above could arrive as a united front, although this is perhaps more likely with the latter two CMEs rather than the former. There is some evidence of a discontinuity in the solar wind as of 23/0300UTC, especially visible in IMF, which may be related to the first of the above events, although this is conjectural, and the event has thus far been very slight in terms of impacts.

Earth is otherwise now exiting the influence of the recent fast wind from CH68/+, with a brief hiatus now expected before a likely more potent fast wind perhaps arrives from equatorial CH69/+, most likely arriving later on Tuesday 24 January, or perhaps early on 25 January with Elevated solar winds. The positive polarity of this feature should perhaps serve to slightly mitigate its potency given our gradual approach to the vernal equinox.

All considered, the risk of Minor Storm G1 intervals comprises a well-spread low peak through the first half of the UTC working week as a consequence of all of the above, with Thursday 26 January perhaps the most reliably Quiet day should no further CMEs materialise.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	40	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/0940	Full	Filament Eruption	NE	500km/s	23/0900UTC	Perhaps the cause of the 23/0300UTC L1 disturbance, faint and low confidence
20/1847	Partial	Filament Eruption	SW	770km/s	23/1200UTC	Possible glancing blow. Medium

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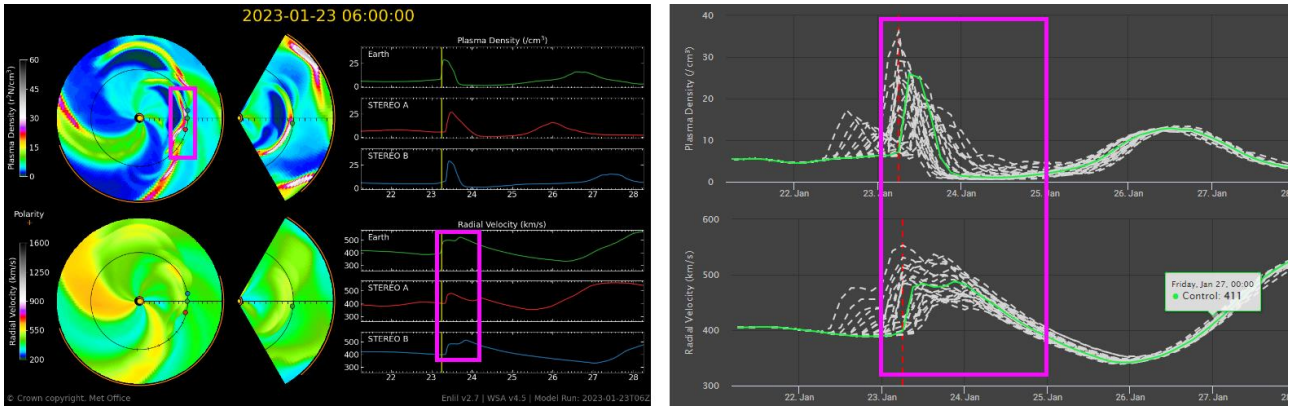
						confidence.
20/2222	Partial	Flare	AR3190 (SW)	450km/s	24/1800UTC	Possible glancing blow, low confidence.

Figure 2: Latest MOSWOC Enlil run and ensemble, showing the earlier two CMEs potentially arriving in short succession within the current UTC day. The final CME is angled largely south of the ecliptic and is therefore not easily visible, but it may influence the other transients. The whole forecast is low confidence, both due to Enlil's omission of any fast wind from newly-developed coronal hole 69, but also because of the inherent high uncertainty in the contributing CME analyses. All considered, the risk of CME influence should largely have abated by midweek UTC.



Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate in the past 24 hours, and similar is considered Likely until at least midweek UTC, whereupon the departure of the largest and most active sunspot group may serve to slightly reduce the risk of further M-class flares.

Far-side soundings and returning Carrington locations continue to hint that arrivals are to be expected over the eastern limb in the period, although these will be assessed as and when they present for analysis. Meanwhile, of greater certainty, both of the current more-active groups (AR3190 and AR3194) should leave the disc after midweek, which has the effect of slightly reducing the risk of flares by Thursday 26 January.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	60	60	60	50
Very Active	**R3 to R5 X Class**	No	5	5	5	1

Figure 3: Helioviewer.org HMIIF running difference imagery, showing the footprints (white T-24h, black 23/1100UTC) of the two most active sunspot regions of the past 24 hours in the southwest:

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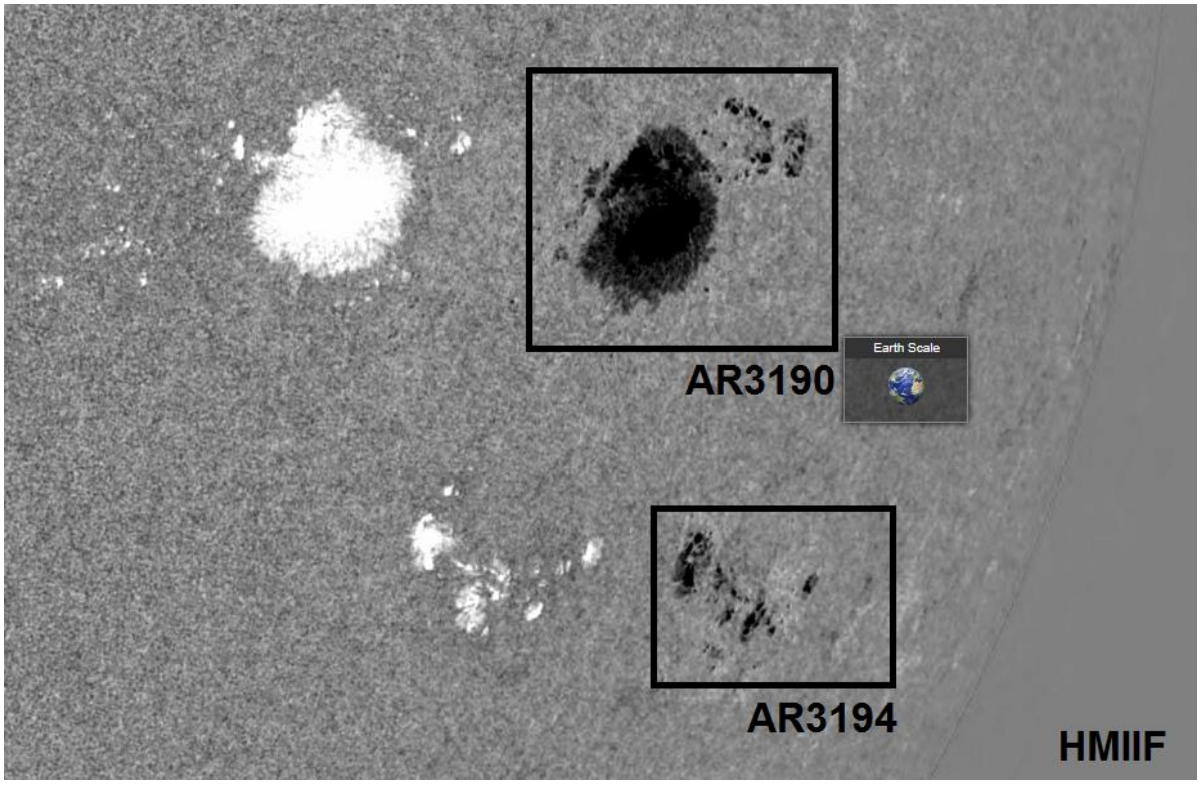
AR3190 and AR3194. Shown for scale are the southwestern limb and the Earth. Note especially the changed distribution of surrounding minor spots in AR3190.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at Background levels, but has breifly ventured to 1pfu in the past few days in response to southwest quadrant activity.

So, while no recent S1+ events (10pfu) have been observed at GEO, the elevated number of front-sided groups and their western solar hemisphere bias dictates an elevated risk. AR3190 contributes most of the risk, and the slight chance of S1 or greater continues through the four-day period.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

Electron flux should remain at Normal Background to Moderate levels, as per its current diurnal oscillation given expected geomagnetic activity from a number of low confidence transients.

The main risk to Active electron fluence being realised in the four days is the expected onset of CH69, which is mooted for 24 January. Because this is a newly-developed feature on this pass, confidence as to its effects and magnitude are both currently low, with the threat of CMEs early in the forecast also serving to reduce confidence further still. Of greater confidence is the fact that the latest available STEREO A MAG and PLASTIC data does suggest that any fast wind remains at least 24 hours away. The effects from the aforementioned fast wind should wane soon after midweek UTC, which ought to provide the peak risk of exceedence for the period as a whole, although this currently remains a Chance given the inherent uncertainties involved.

MOSWOC REFM is not considered particularly useful guidance at present given the relative dominance of non-persistent features in the forecast, however it suggests a steady trend below Active through the next 72 hours.

GEO Electron Environment / **Probability (Exceedance)**	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** / **(%)**	**Day 2 (00-24 UTC)** / **(%)**	**Day 3 (00-24 UTC)** / **(%)**	**Day 4 (00-24 UTC)** / **(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	5	5	20	40
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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